Introduction

The 2004 VLAP Sampling Season

The Volunteer Lake Assessment Program (VLAP) had another successful sampling season in 2004. A total of 154 lakes and ponds were tested by volunteer monitors throughout the state. In addition, approximately 450 volunteer monitors participated in the program!

DES would like to extend a special welcome to the monitoring group from Marsh Pond, Chichester, who joined VLAP for the first time this year. And, we welcome back our friends and monitors at Frost Pond in Jaffrey and Seavey Pond in Windham, who rejoined VLAP during the 2004 season.

2004 Weather Conditions in New Hampshire

Overall, the 2004 Summer was cooler than normal. May and June were rainy which likely increased nutrient loading and increased algal growth in some New Hampshire lakes and ponds. In May and June, many groups reported lower (meaning worse) Secchi disk transparency readings while chlorophyll concentrations for these lakes and ponds showed above normal levels. Due to the prevalence of spring and early summer rain and the relatively cooler air temperatures which prevailed throughout most of the summer, the surface water temperature measured in most of the lakes and ponds during the annual biologist visit was cooler than temperatures measured in previous summers.

2004 Program Updates

The DES Environmental Monitoring Database and Station Naming

As of the Spring of 2004, all current year and historical VLAP data is included in the new DES Environmental Monitoring Database (EMD). To facilitate the transfer of VLAP data into the EMD, a new station identification system had to be developed. During the 2004 sampling season, many of you noticed that the DES Chemistry Laboratory began to use a new station name (the EMD station name) to identify each sampling station. The EMD station name generally consists of the first three letters of your lake or pond, the first three letters of the town the station is physically located in, and finally a couple of letters or numbers to identify the specific station. While monitoring groups can still use the sampling station names that they have used in the past (and are most familiar with) to identify sampling locations, the DES Chemistry Laboratory will continue to report the phosphorus and *E.coli* results using the EMD station name. (As with the 2004 sampling season, during the 2005 sampling season, the VLAP coordinator will send laboratory reports with the station names that you are familiar with as well as the corresponding EMD station names).

Since all of the historical and current year VLAP data is now included in the DES EMD, your monitoring group (along with anyone else in the world!) can access the data for your lake/pond through the DES website. To access the data on the website simply follow the instructions listed below:

1. Go to the DES website at http://www.des.state.nh.us.
2. Click on "OneStop Data" which is located on the left hand side of the page.
3. Click on "Go to OneStop Data Retrieval Site" which is located on the bottom of the page.
4. Click on "Environmental Monitoring" data which is at the bottom of the left hand column.
5. Fill out the pertinent information for the data you are requesting. Please note that you must supply an email address where you would like the data to be sent.
6. After you have entered all of the pertinent information, hit the "Submit Query" button which is located at the bottom of the screen page.

2004 Report Updates

New Station Map

In Appendix C, you will find two maps for your lake or pond. One map is the bathymetric map which shows the depth contours. The other map is a new station map which shows all the sampling stations for your lake or pond, including the tributary and the deep spot sampling locations. In the Spring of 2004, we asked your monitoring group to review and update the sampling station map for your lake or pond. We want to thank you for taking the time to review your map and to make corrections as necessary. The location of all current and historical sampling locations (when possible) for each lake and pond sampled through VLAP is being incorporated into the DES Geographical Information Systems (GIS) database. Eventually, through the DES GIS website, you will be able to click on a map of your lake or pond and all of the water quality data for each station will be available! ***If there are still stations that are missing from your station map, or are not located in the proper place, please make corrections to the map and send it to the VLAP Coordinator.***

VLAP Report Tables

You may notice that the report tables have a slightly new format this year. Since VLAP data is now included in the EMD, a different software program is used to generate the data tables. These tables contain the same type of information that has been included in the past. Gridlines are now provided to help you read the tables. In some tables you will see that the EMD station name is used in addition to the station name your group typically uses to identify stations (this is necessary for lakes with two or more deep spots).

Table 12 (*E.coli*) has been expanded to include the current year and all historical maximum and minimum *E.coli* concentrations. Many monitors have asked us to include the historical *E.coli* data and we are happy to report that, with the new database, we are finally able to do this!

Three new tables have been added to the annual report this year! Table 13 is included for monitoring groups who collect chloride samples. Table 14 contains the current year chemical and biological raw data. Table 15 contains the list of sampling station names that you are familiar with and their corresponding EMD station names. While monitoring groups can still use the sampling station names that they have used in the past, the DES chemistry lab will continue to report phosphorus, *E.coli*, and chloride results using the EMD station name. Therefore, Table 15 should be very helpful!

Concluding Remarks

Please read the "Observations and Recommendations" and "Data Quality Assessment & Quality Control" sections of your report carefully, and pay special attention to the suggestions that we have made to improve your current sampling program.

In Appendix D, you will find this year's Special Topic Article, "Conductivity is on the rise in New Hampshire's Lakes and Ponds: What is causing the increase and what can be done?". The conductivity level in many of the lakes and ponds throughout the state, particularly in the more developed areas of the state and near major roadways, is increasing at a rapid rate. We would like to encourage monitoring groups with increasing conductivity levels to expand their sampling program to include conductivity surveys and chloride sampling so that DES can determine what may be causing the increases. For more information about these types of sampling, please be sure to read this article.

We realize that there is a lot of information to digest in the following pages. If you have any questions regarding your 2004 report, please give the VLAP Coordinator a call. And finally, please contact the VLAP Coordinator this spring to schedule the annual biologist visit to your lake or pond.

Sincerely,

Andrea LaMoreaux
VLAP Coordinator
Tel: (603) 271-2658
Email: alamoreaux@des.state.nh.us

Jody Connor
Limnology Center Director
Tel: (603) 271-3414
Email: jconnor@des.state.nh.us

How to Interpret Graphs and Tables

Graphs

Observation: a sample or data point

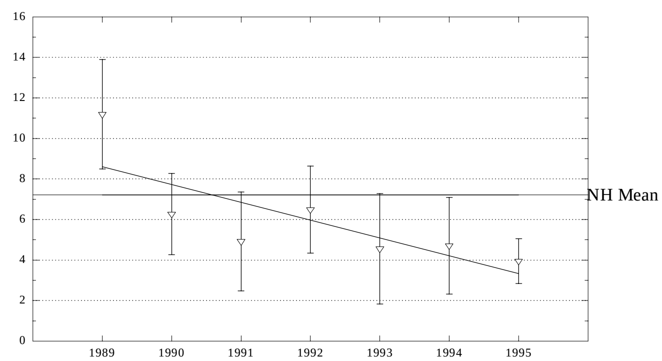
There are two types of graphs in Appendix A of this report, a line graph and bar graph. Each graph conveys much more to the reader than a table or verbal description, so it is important to be able to interpret it correctly. It must be stressed that a fewer number of **observations** causes a corresponding decline in the reliability of the information (the more data the better!).

Line Graph

Mean: average. To calculate the mean, the reading or concentration for a particular parameter on each sampling event is added together, which results in a total for the season. The season total is then divided by the number of sampling events during the season, which results in an average concentration or reading per sample event.

The line graph summarizes sampling results for the years you have collected data (see sample line graph below). The graph shows the **mean** for a given year as an up-turned or down-turned triangle. The triangle points in the direction of more desirable values. For example, chlorophyll-a and total phosphorus have downward triangles, indicating lower values are better, while transparency has upward triangles, signifying higher values are more

Line Graph Depicting Historical Data



Standard deviation: a statistic measuring the spread of the data around the mean

Range: difference between the high and low values

A measure of the spread of the data around the mean, or **standard deviation**, is shown as the vertical lines extending up and down from the mean. Standard deviation is similar to **range** except standard deviation is a more exact measure of variation. In this case, the lines indicating standard deviation on your graphs illustrate the amount of variation in the results for a particular test for all the times you sampled in that year. For example, if all the chlorophyll readings came back with similar results each time you sampled this year, then the amount of deviation from the average would be small. If there was a wide range of chlorophyll concentrations in the lake, then the deviation would be large.

Regression Line: a statistical tool used to predict trends in data

Trends in the yearly data can be discerned by looking at the **regression line** and noting its direction and degree of slant (see example next page). If the line is slanted downward (like this "\"), it indicates an improving trend in chlorophyll-a and total phosphorus but a declining trend in transparency values. If the line is sloped the opposite way (like this "/"), it depicts a worsening trend in chlorophyll-a and phosphorus, but an improving trend in transparency values. The steeper the regression line's slope the stronger the trend. A horizontal regression line indicates the parameter presented is stable, neither improving nor worsening over time.

Caution is warranted when drawing absolute conclusions from annual data if the lake data set is small. Don't panic if the line graph shows a parameter worsening — check your raw data first. Look for years with one extremely high or low sampling point; this could **skew** the trend line. Remember, you need many years of data before trends become apparent, and ten years before they are considered statistically significant. After your lake or pond has been monitored through VLAP for at least 10 consecutive years, we will analyze the in-lake data with a simple statistical test. Specifically, we will use a linear regression line and regression statistics to determine if there has been an increase or decrease of the annual mean for chlorophyll-a, Secchi-disk transparency, and total phosphorus in your lake/pond since monitoring began.

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Skew:a measurment of consistency, or more precisely, the lack of consistency

The last element in the line graph is a line representing the **New Hampshire mean** for that particular parameter. The data from your lake can be compared to this value. For a complete summary of water quality test averages in New Hampshire, please turn to page 10.

NH Mean: data collected from approximately 800 lakes in the state for the NH Lake Survey Program

Bar Graph

The second type of graph found in this report is the bar graph. It represents this year's monthly data for a given parameter. When more than one sampling event occurred in a month, the plotted value will represent **an average result for that month (this is a new change starting with the 2004 annual report)**. Please check your raw data reports to find all of the results. The bar graph emphasizes individual values for comparison rather than overall trends and allows easy data comparisons within one sampling season.

Tables

Tables in Appendix B summarize data collected during 2004 and previous years. Maximum, minimum, and mean values are given for each station by sampling year for most tests, where applicable.

Lake Maps

A **bathymetric map** in Appendix C shows the depth contours of your lake. The "X" denotes the deepest spot in your lake, where most of the in-lake sampling is done. A station map in Appendix C shows the name and location of the tributary and deep spot samples collected from your lake. Tributary names for major inlets and outlets are labeled on the map, and should be referred to when labeling sample bottles and studying the data in Appendix B. If any stations are missing, please make corrections to the map and send it to the VLAP Coordinator.

Bathymetric map: a map which shows the topography of the lake's bottom; contours depict lake depths

Interpreting Data

Lake aging: natural process by which a lake fills-in over time

Watershed: land draining to a particular water body; often described as a funnel

Eutrophication: lake aging accelerated by increased nutrient input exceeding the natural supply

Fertility: capacity to sustain plant growth

Biological Production: total amount or weight of living plants and animals

Limiting nutrient: nutrient that in small increases can cause larger changes in biological production

Oligo: little

Trophic: food

Oligotrophic: low biological production and nutrients; highest lake classification

Eutrophic: high biological production, nutrient rich; lowest lake classification

Cultural eutrophication: when increaed nutrient input and debris into a lake is caused by human activity

Impervious: impenetrable

Epilimnetic: upper water layer

Hypolimnetic: lower water layer

Anoxia: no oxygen present

Like all of us, lakes age over time. **Lake aging** is the natural process by which a lake fills in over geologic time. They fill-in with erosional materials carried in by the tributary streams, with materials deposited directly through the air, and with materials produced in the lake itself. From the time that a lake is created, the aging or filling-in process begins. Although many New Hampshire lakes have the same chronological age, they change and fill-in at different rates because of differences in runoff and **watershed** characteristics. Lakes can fill-in more quickly than natural due to human impacts. **Eutrophication** is the process of increased nutrient input to a lake exceeding the natural supply. The **fertility** of the watershed, which is dependent upon land use and geology, determines the rate of lake aging. Increased lake fertilization results in an increase in **biological production**.

The key chemical in the eutrophication process is the nutrient phosphorus. Phosphorus is the **limiting nutrient** in New Hampshire lakes; the greater the phosphorus concentration in a lake, the greater the biological production. Biological production can be measured in terms of plant growth, algal growth, decreased transparency, and an overall decrease in lake quality.

It is very important to understand the meaning of biological production when referring to lakes. We often think of biological production as something good. For example, a productive garden yields an abundance of vegetables. But, when speaking about lake productivity, usually the low biological production associated with a clear, **oligotrophic** lake is the ideal condition. Fisherman, on the other hand, may prefer a productive lake, especially if they are fishing for warm water species, such as bass. Warm water species thrive in productive lakes because of the abundance of food and presence of plants used for protection and spawning. Excessive plant growth and algae blooms are present in a *highly* productive, **eutrophic** lake.

When eutrophication is caused by human activity it is termed **cultural eutrophication**. This accelerated aging results from watershed activities that increase nutrient loading or the deposition of other debris, such as fertilizing, converting forest or pasture to cropland, and creating **impervious** areas such as rooftops, parking lots, and driveways. Studies in New Hampshire have shown that phosphorus exports from agricultural lands is at least 5 times greater than from forested lands, and in urban areas may be more than 10 times greater. Other contributers to cultural eutrophication include septic systems, lawn fertilizer, bathing in or near the lake, sediment erosion into the lake, dumping or burning leaves and trees in or near a lake, and feeding ducks.

As you interpret the data on the following pages, pay close attention to the trends. Look for increases or decreases in the **epilimnetic** and **hypolimnetic** phosphorus. If you observe an increase in hypolimnetic phosphorus as the summer progresses, a process called internal phosphorus loading is occurring. This means phosphorus that was tied up in the lake floor sediments is now able to enter the water column. **Anoxia** initiates this process.

What if there was an increase in epilimnetic phosphorus? As you look at the data from the inlets, notice if this year's data show an increase in phosphorus from a particular inlet. If the increase is large, the new source of phosphorus should be investigated. Investigations may include a watershed walk or bracketing the brook for further sampling.

Transparency: water clarity

Chlorophyll-a: green pigment found in plants; used to measure the amount of algae in a lake

Correlations between **transparency** and **chlorophyll-a** are important. If the chlorophyll-a increased and the Secchi disk transparency decreased increased algae populations are affecting the water clarity. If the chlorophyll-a has not increased, but the transparency has undergone a decline (for example, a reading from four meters down to two meters) the reduced transparency could be attributed to turbidity caused by stream inputs, motorboat activity, shoreline construction, or disturbances of bottom sediments. In shallow lakes, less than 15 feet in depth, the wind can produce wave action that can disturb the bottom sediment creating high turbidity.

Non-point pollution: pollution originating in the watershed, often entering the water body via surface runoff or groundwater

Conductivity, acid neutralizing capacity (ANC), and pH should also be examined. Conductivity is a good indicator of disturbance or **non-point sources** of pollution. The lower the pH or ANC value for your lake the more vulnerable it is to acid precipitation. A marked increase or decrease in any parameter should be investigated.

Epilimnion: upper water layer

Metalimnion: middle water layer (a.k.a. thermocline)

Hypolimnion: bottom water layer

All of the data might seem overwhelming to you at the start. First, take a look at the in-lake data. The tables in Appendix B will list in-lake data either as **Epilimnion, Metalimnion,** or **Hypolimnion.** The number of layers formed in a given year is dependent upon lake depth and seasonal temperatures; if your lake has two layers, only epilimnetic and hypolimnetic data will be displayed, or epilimnetic data only if the lake is too shallow to form layers. Follow the trends within each layer and note any changes for each parameter.

Tributary: stream, inlet

Then examine the **tributary** data. Look at each inlet, one at a time. Some will likely reflect good conditions (low total phosphorus, low conductivity, and pH between 6.0 and 7.0). Others might reflect poor tributary quality, sending off a warning light (high total phosphorus, high conductivity, or low pH). List the possible problems you identified from your data and prioritize them according to your association's goals. Keep in mind that weather patterns during the sampling season will strongly affect the lake quality. Heavy rainfall or large amounts of snow-melt can result in nutrient-rich and sediment-laden runoff to the lake. On the other hand, a dry season will have an absence of such runoff, potentially resulting in less nutrients to feed algae and plant growth and greater water clarity.

Weather patterns should be carefully considered when assessing lake changes from year to year, and even within a sampling season. Large variations in sample results may be observed from month to month when comparing a wet summer month to a dry month.

Biological: living plants or organisms

Chemical: parameters related to the chemistry of water

Physical: parameters that can be percepted using the senses, such as Secchi disk transparency

To provide an understanding of how your water body compares to other New Hampshire lakes the following table summarizes key **biological, chemical, and physical** parameters for all the state's lakes surveyed since 1976.

Characteristics of New Hampshire Lakes and Ponds

Summer Epilimnetic Values

Parameter	#*	Min	Max	Mean	Median
pH (units)	780	4.3	9.3	**6.5	6.6
Alkalinity (mg/L)	781	-3	85.9	6.6	4.9
Total Phosphorus (ug/L)	772	1	121	-	12
Conductivity (umhos/cm)	768	13.1	696	59.4	40.0
Chloride (mg/L)	742	<2	198	-	4
Chlorophyll-a (mg/m3)	776	0.19	143.8	7.16	4.58
Secchi Disk (m)***	663	0.40	13	3.7	3.2

* = *the number of lake stations sampled*

** = *average pH reading; not average of hydrogen ion concentration*

*** = *does not include 'visible on bottom" readings*

Finally, refer to the Observations and Recommendations section of this report, which discusses the basic trend data and also lists some suggestions for future sampling. Then, formulate a plan and call us for guidance. Once you know where your concerns lie, we will work with you to modify your current sampling program to address these goals. You may also be eligible to be involved in the New Hampshire Clean Lakes Program (NHCLP) which provides more detailed watershed diagnostic tests and recommends Best Managment Programs to reduce pollutants to the lake. The NHCLP can lead to watershed management programs through the Local Initatives Grants offered by DES. Don't procrastinate too long; summer will be here before you know it!

Monitoring Parameters

Biological Parameters

Algal Abundance

Algae are photosynthetic plants that contain chlorophyll but do not have true roots, stems, or leaves (a.k.a. "phytoplankton"). They do, however, grow in many forms such as aggregates of cells (colonies), in strands (filaments), or as microscopic single cells. They may also be found growing on objects, like rocks or vascular plants, in the bottom sand or free-floating in the water column.

Photosynthesis: producing carbohydrates with the aid of sunlight

Food chain: arrangement of organisms in a community according to the order of predation

Oxygenated: holding oxygen in solution

Regardless of their form, these primitive plants carry out **photosynthesis** and accomplish two very important roles in the process. First, inorganic material is converted to organic matter. These tiny plants then form the base of a lake **food chain**. Microscopic animals (zooplankton) graze upon algae like cows graze on grass in a field. Fish also feed on the algae along with other aquatic organisms. Second, the water is **oxygenated**, aiding the chemical balance and biological health of the lake system.

Algae require light, nutrients, and certain temperatures to thrive. All of these factors are constantly changing in a lake from day to day, season to season, and year to year. Therefore, algae populations and the abundance of individual species of algae naturally fluctuate with weather changes or changes in lake quality.

Chlorophyll-a: a green pigment found in algae

Oligotrophic: low biological production

Eutrophic: high biological production; nutrient rich

Mean: average

VLAP uses the measure of **chlorophyll-a** as an indicator of the algae abundance. Because algae is a plant and contains the green pigment chlorophyll, the concentration of chlorophyll found in the water gives us an estimation of the concentration of algae. If the chlorophyll-a concentration increases, this indicates an increase in the algal population. Generally, a chlorophyll-a concentration of less than 4 mg/m^3 indicates water quality conditions that are representative of **oligotrophic** lakes, while a chlorophyll-a concentration greater than 15 mg/m^3 indicates **eutrophic** conditions. A chlorophyll concentration greater than 10 mg/m^3 generally indicates an algae bloom (excessive reproduction of algae).

The **mean** chlorophyll-a concentration for New Hampshire lakes is 7.16 mg/m^3. Figure 1 (Appendix A) and Table 1 (Appendix B) present the mean chlorophyll-a concentration for each year of participation in VLAP. Table 1 also presents the minimum and maximum values recorded for the same years.

Chlorophyll-a (mg/m3)	
0-5	Good
5.1-15	More than desirable
>15	Nuisance amounts

Phytoplankton

Phytoplankton: microscopic algae floating in the water column

Plankton net: fine mesh net used to collect microscopic plants and animals

Periphyton: an assemblage of microorganisms (plants and animals) firmly attached to and growing upon solid surfaces such as the bottom of a lake or stream, rocks, logs, and structures.

Succession: the decline of dominant species of algae over a period of time as another species increases and becomes dominant

The type of **phytoplankton** present in a lake can be used as an indicator of general lake quality. The most direct way to obtain phytoplankton information involves collection of a sample with a **plankton net**, measurement of the quantity of phytoplankton contained in the sample, and identification of the species present using a microscope. An abundance of cyanobacteria, such as *Anabaena, Aphanizomenon, Oscillatoria,* or *Microcystis* may indicate excessive phosphorus concentration or that the lake ecology is out of balance. On the other hand, diatoms such as *Asterionella, Melosira,* and *Tabellaria* or golden-brown algae such as *Dinobryon* or *Chrysosphaerella* are typical phytoplankton of New Hampshire's less productive lakes. In shallow warm waters with minimal wave action (such as a cove), filamentous green algae may grow in a form that looks like a mass of green cotton candy. **Periphyton** may grow on rocks or vegetation, causing these to be slippery.

Phytoplankton populations undergo a natural **succession** during the growing season. Many factors influence this succession: amount of light, availability of nutrients, temperature of the water, and the amount of grazing occurring from zooplankton. As shown in the diagram on the next page, it is natural for diatoms to be the dominant species in the spring and then green algae in the early summer, while cyanobacteria may dominate in mid to late summer. The plankton samples from your lake will show different dominant species, depending on when the samples were taken. Phytoplankton are identified in Table 2 in Appendix B. Phytoplankton groups and species are listed below.

Phytoplankton Groups and Species for New Hampshire Lakes and Ponds

Greens

Actinastrum	*Eudorina*	*Pandorina*	*Spirogyra*
Arthrodesmus	*Kirchneriella*	*Pediastrum*	*Staurastrum*
Dictyosphaerium	*Micractinium*	*Scenedesmus*	*Stigeoclonium*
Elakotothrix	*Mougeotia*	*Sphaerocystis*	*Ulothrix*

Diatoms

Asterionella	*Melosira*	*Rhizosolenia*	*Synedra*
Cyclotella	*Pleurosigma*	*Surirella*	*Tabellaria*
Fragilaria			

Dinoflagellates

Ceratium	*Peridinium*	*Gymnodinium*

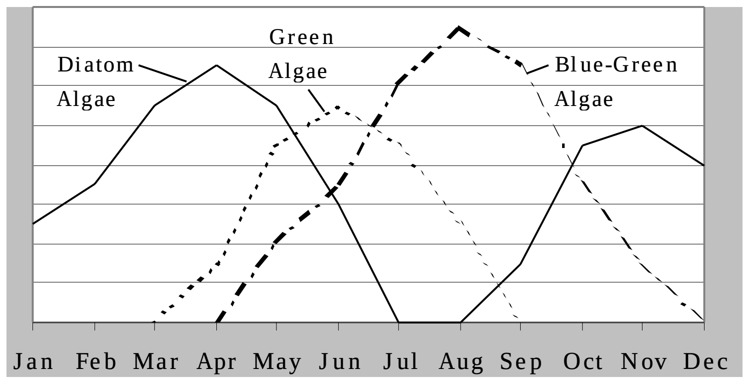
Cyanobacteria (formerly known as blue-green algae)

Anabaena	*Chroococcus*	*Gloeotrichia*	*Microcystis*
Aphanizomenon	*Coelosphaerium*	*Lyngbya*	*Oscillatoria*
Aphanocapsa			

Golden-Browns

Chrysosphaerella	*Mallomonas*	*Synura*	*Uroglenopsis*
Dinobryon			

A Typical Seasonal Succession of Lake Algae



Cyanobacteria

Cyanobacteria are bacterial microorganisms that photosynthesize. Many species of cyanobacteria may accumulate to form surface water "blooms". They produce a blue-green pigment but may impart a green, blue, or pink color tothe water. Cyanobacteria are some of the earliest inhabitants of our waters, and they are naturally occurring in all of our lakes. However, research indicates that their abundance increases as the phosphorus in a lake increase. They are part of the aquatic food web and can be eaten by various grazers in the lake ecosystem, such as **zooplankton** and mussels.

Although they are most often seen when floating near the surface, many cyanobacteria species spend a portion of their life cycle on the bottom of the lake during the winter months. As spring provides more light and warmer temperatures, cyanobacteria move up the water column and eventually rise toward the surface where they can form dense blooms or scums, often seen in mid to late summer and, weather permitting, sometimes well into the fall.

Some cyanobacteria produce toxins that adversely affect livestock, domestic animals, and humans. According to the World Health Organization (WHO), toxic cyanobacteria are found worldwide in both inland and coastal waters. The first reports of toxic cyanobacteria in New Hampshire occurred in the 1960s and 1970s. During the summer of 1999, several dogs died after ingesting toxic cyanobacteria from a bloom in Lake Champlain in Vermont. The WHO has documented acute impacts to humans from cyanobacteria from the U.S. and around the world as far back as 1931. While most human health impacts have resulted from ingestion of contaminated drinking water, cases of illnesses have also been attributed to swimming in waters infested with cyanobacteria.

Cyanobacteria: Bacterial microorganisms that photosynthesize and may produce chemicals toxic to other organisms, including humans. They have the ability to produce their own nitrogren. They have the ability to produce gases to move vertically through the water column. Some have structures that fall to the sediment when environmental conditions in the water column are not condusive for growth and can regenerate when water column conditions are more favorable.

Zooplankton: Small, usually microscopic animals found in lakes and reservoirs that possess little or no means of propulsion. Consequently, animals belonging to this class drift along with the currents.

The possible effects of cyanobacteria on the "health" of New Hampshire lakes and their natural inhabitants, such as fish and other aquatic life, are under study at this time. The Center for Freshwater Biology (CFB) at the University of New Hampshire (UNH) is currently examining the potential impacts of these toxins upon the lake food web. The potential human health hazards via exposure through drinking water and/or during recreational water activities are also a concern to the CFB and DES.

Neurotoxin: nerve toxins

Hepotoxins: liver toxins

Dermatoxins: toxins that cause skin irritations

Cyanobacteria occur in all lakes, everywhere. There are many types of cyanobacteria in New Hampshire lakes. Most cyanobacteria do not have the ability to produce toxins. In New Hampshire, there are several common cyanobacteria that include: *Gleotrichia, Merismopeida, Anabaena, Oscillatoria, Coelospharium, and Microcystis*. Only five cyanobacteria have been associated with producing toxins. These five toxin producers include: *Anabaena, Aphanizomenon, Oscillatoria, Microcystis,* and *Lyngbya*. *Anabaena* and *Aphanizomenon* produce **neurotoxins** that interfere with the nerve function and have almost immediate effects when ingested. *Microcystis* and *Oscillatoria* are best known for producing **hepatotoxins** known as microcystins. *Oscillatoria* and *Lyngbya* produce **dermatotoxins**, which cause skin rashes.

Both DES and UNH have extensive lake monitoring programs. Generally, the water quality of New Hampshire's lakes is very good. However, DES strongly advises against using lake water for consumption, since neither in-home water treatment systems nor boiling the water will eliminate cyanobacteria toxins if they are present.

If you observe a well-established potential cyanobacteria bloom or scum in the water, please comply with the following:

- Do not wade or swim in the water!
- Do not drink the water or let children drink the water!
- Do not let pets or livestock into the water!

Exposure to toxic cyanobacteria scums may cause various symptoms, including nausea, vomiting, diarrhea, mild fever, skin rashes, eye and nose irritations, and general malaise. If anyone comes in contact with a blue-green algae bloom or scum, they should rinse off with fresh water as soon as possible.

If you observe a blue-green algae bloom or scum, please call DES at 271-3414. DES will sample the scum and determine if it contains cyanobacteria that are associated with toxic production. An advisory will be posted on the immediate shoreline indicating that the area may not be suitable for swimming. DES will notify the town health officer, beach manager, and/or property owner, and the New Hampshire Department of Health and Human Services. DES will continue to monitor the water and will notify the appropriate parties regarding the results of the testing. When monitoring indicates that cyanobacteria are no longer present at levels that could harm humans or animals, the advisory will be removed.

Secchi Disk Transparency

The Secchi disk is a 20 centimeter disk with alternating black and white quadrants. It has been used since the mid-1800s to measure the transparency of water. The Secchi disk is named after the Italian professor P.A. Secchi whose early studies established the experimental procedures for using the disk. The disk is used to measure the depth that a person can see into the water. Transparency, a measure of the water clarity, is affected by the amount of algae, **color**, and particulate matter within a lake. In addition, the transparency reading may be affected by wave action, sunlight, and the eyesight of the volunteer monitor. Therefore, we recommend that two or three monitors take a Secchi disk reading, and then these readings should be averaged. In general, a transparency greater than 4.5 meters indicates oligotrophic conditions, while a transparency of less than 2 meters is indicative of eutrophic conditions.

Color: apparent water color caused by dissolved organic compounds and suspended materials

The mean transparency for New Hampshire lakes is 3.7 meters (one meter equals 3 feet, 4 inches). Figure 2 in Appendix A presents a comparison of the transparency values for each of the VLAP monitoring years, while Table 3 of Appendix B shows the minimum, maximum, and mean values for all years of participation.

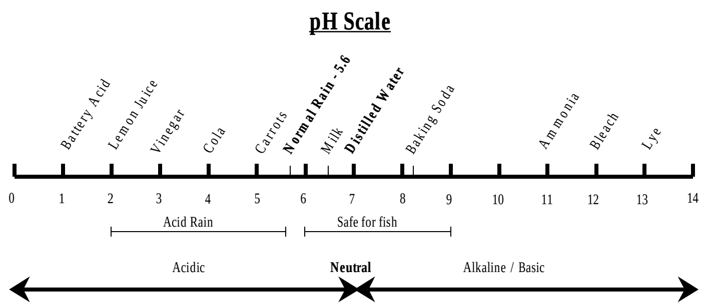
Water Clarity (Transparency) Ranges for Lakes and Ponds

Category	Water Clarity (m)
Poor	<2
Good	2-4.5
Exceptional	>4.5

Chemical Parameters

pH

pH is measured on a logarithmic scale of 0 to 14. The lower the pH the more acidic the solution, due to higher concentrations of hydrogen ions. Acid rain typically has a pH of 3.5 to 5.5 due to pollutants added from the air. In contrast, the median pH for New Hampshire lakes is 6.6.



Lake pH is important to the survival and reproduction of fish and other aquatic life. A pH below 5.0 severely limits the growth and reproduction of fish. A pH between 6.0 and 7.0 is ideal.

Thermally stratified: water layered by temperature differences. During the summer, cooler, more dense water is typically found closer to the lake bottom, while warmer, less dense water is found closer to the lake surface.

Bacteria: tiny organisms that break down dead matter

Phytoplankton: microscopic algae floating in the water column

Many lakes exhibit lower pH values in the deeper waters than nearer the surface. This effect is greatest in the bottom waters of a **thermally stratified** lake. Decomposition carried out by **bacteria** in the lake bottom causes the pH to drop, while photosynthesis by **phytoplankton** in the upper layers can cause the pH to increase. Tannic and humic acids released to the water by decaying plants can create more acidic waters in areas influenced by wetlands. After the acidic spring-time snow melt or a significant rain event, surface waters may have a lower pH than deeper waters and may take several weeks to recover. (Snowmelt and rainfall typcially have pH values of 4 or lower.)

Table 4 in Appendix B presents the in-lake and tributary true mean pH data.

pH Ranges for New Hampshire Lakes and Ponds

Category	pH (units)
Critical (toxic to most fish)	<5
Endangered (toxic to some aquatic organisms)	5-6
Satisfactory	>6

Acid Neutralizing Capacity

Buffering capacity or Acid Neutralizing Capacity (ANC) describes the ability of a solution to resist changes in pH by neutralizing the acidic input to the lake. The higher the ANC the greater the ability of the water to neutralize acids. This concept can be compared to a person taking an antacid, to neutralize stomach acid indigestion. Low ANC lakes are not well buffered. These lakes are often adversely affected by acidic inputs.

Historically, New Hampshire has had naturally low ANC waters because of the prevalence of granite bedrock. (Granite does not contain elements that have buffering capacity, like limestone.) The average ANC for New Hampshire lakes is 6.6 mg/L. This relatively low value makes them vulnerable to the effects of acid precipitation. Table 5 in Appendix B presents the mean epilimnetic ANC for each year your association has been involved in this program.

Acid Neutralizing Capacity Ranges for New Hampshire Lakes and Ponds

Category	ANC (mg/L)
Acidified	<0
Extremely Vulnerable	0-2
Moderately Vulnerable	2.1-10
Low Vulnerability	10.1-25
Not Vulnerable	>25

Conductivity

Ionic paricle(s): an atom or group of atoms carrying an electrical charge

Conductivity is the numerical expression of the ability of water to carry an electrical current. It is determined primarily by the number of **ionic particles** present. The soft waters of New Hampshire have traditionally had low conductivity values. High conductivity may indicate pollution from such sources as road salting, faulty septic systems, or urban/agricultural runoff.

Erosion: soil materials worn away by the action of water or wind

Specific categories of good and bad levels cannot be constructed for conductivity, because variations in watershed geology can result in natural fluctuations in conductivity. However, values in New Hampshire lakes exceeding 100 umhos/cm generally indicate cultural (man-made) sources of ions. The conductivity should remain fairly constant for a given lake throughout the year. Any major changes over a short period of time may indicate **erosion** resulting from heavy rain or a large flush of runoff from a problem site. Conductivity less than 50 umhos/cm is typical of oligotrophic lakes. Conductivity greater than 100 umhos/cm is more typical of lakes with greater human impacts.

The mean conductivity for New Hampshire lakes is 59.4 umhos/cm. Table 6 in Appendix B presents mean conductivity values for tributaries and in-lake data.

Phosphorus

Phosphorus is the most important water quality parameter measured in our lakes. It is this nutrient that limits the algae's ability to grow and reproduce. Limiting phosphorus in a lake will result in lower or reduced, natural algae concentration. Increased phosphorus levels encourage excessive plant growth and **algal blooms.** Phosphorus occurs in many forms in a lake and is absorbed by algae, becoming part of a living cell. When the algae cell dies the phosphorus is still organically bound, even as the dead cells settle to the lake bottom.

Algal blooms: over-population of algae

Phosphorus sources around a lake include septic systems, animal waste, lawn fertilizer, road and construction erosion, natural wetlands, and atmospheric deposition.

An in-lake epilimnetic (upper layer) phosphorus concentration of less than 10 ug/L indicates oligotrophic conditions, while a concentration greater than 20 ug/L in the epilimnion is indicative of eutrophic conditions. The **median** phosphorus concentration in the epilimnion layer of New Hampshire lakes is 12 ug/L. The **median** phosphorus concentration in the hypolimnion (lower layer) is 14 ug/L.

Median: a value in an ordered set of values below and above which there is an equal number of values

Figure 3 in Appendix A shows the epilimnetic and hypolimnetic total phosphorus values for 2004 and the historical data. Table 8 in Appendix B presents mean total phosphorus data for in-lake and tributary data.

Total Phosphorus Ranges for New Hampshire Lakes and Ponds (Epilimnetic)

Category	TP (ug/L)
Ideal	<10
Average	11-20
More than desirable	21-40
Excessive	>40

Dissolved Oxygen and Temperature

The presence of dissolved oxygen is vital to bottom-dwelling organisms as well as fish and amphibians. If the concentration of dissolved oxygen is low, species intolerant (meaning sensitive) to this situation, such as trout, will be forced to move up closer to the surface (where the water column is generally warmer) and may not survive.

Temperature is also a factor in the dissolved oxygen concentration. Water can hold more oxygen at colder temperatures than at warmer temperatures. Therefore, a lake will typically have a higher concentration of dissolved oxygen during the winter, spring, and fall than in the summer.

Thermal stratification: water layering by temperature

ppm: parts per million; equal to mg/L

Internal phosphorus loading: addition of phosphorus to the hypolimnion from the lake sediments due to low oxygen conditions

Thermocline: barrier between warm surface layer (epilimnion) and cold deep layer (hypolimnion) where a rapid decrease in water temperature occurs with increasing depth

At least once during this summer, a DES biologist measured the dissolved oxygen and temperature at set intervals from the bottom of the lake to the surface. These measurements allow us to determine the extent of **thermal stratification** as well as the lake oxygen content. Many of the more productive lakes experience a drop in dissolved oxygen in the deeper waters as the summer progresses. Bacteria in the lake sediments decompose the dead organic matter that settles out, a process that depletes oxygen in the bottom waters. Since more productive lakes tend to have organic-rich sediments there will be greater decomposition on the bottom of such lakes, potentially creating a severe dissolved oxygen deficit (less than 1 **ppm**). This low oxygen condition can then trigger phosphorus that is normally bound to the sediment to be released into the water (**internal phosphorus loading**).

Dissolved oxygen percent saturation shows the percentage of oxygen that is dissolved in the water at a particular depth. Typically, the deeper the reading the lower the percent saturation. A high reading at or slightly above the **thermocline** may be due to a layer of algae, producing oxygen during photosynthesis. Colder waters are able to hold more dissolved oxygen than warmer waters, and generally, the deeper the water the colder the temperature. As a result, a reading of 9 mg/L of oxygen at the surface will yield a higher percent saturation than a reading of 9 mg/L of oxygen at 25 meters, because of the difference in water temperture. Table 9 in Appendix B illustrates the Dissolved Oxygen/Temperture profile(s) for 2004, and Table 10 shows historical hypolimnetic dissolved oxygen readings.

Chloride

Salt-water intrusion: invasion of a body of fresh water by a body of salt water, due to its greater density. It can occur either in surface or ground-water bodies. The term is applied to the flooding of freshwater marshes by seawater, the migration of seawater up rivers and navigation channels, and the movement of seawater into freshwater aquifers along coastal regions.

The chloride ion (Cl^-) is found naturally in some surface waters and groundwaters and in high concentrations in seawater. Higher-than-normal chloride concentrations in fresh water, due to sodium chloride (table salt) that is used on foods and present in body wastes, can indicate sewage pollution. The use of highway deicing salts can also introduce chlorides to surface water or groundwater. Elevated groundwater chlorides in drinking water wells near coastlines may indicate **saltwater intrusion**.

In New Hampshire, the application of road salt for winter accident prevention is a large source of chloride to the environment, which is increasing over time due to the expansion of road networks and increased vehicle traffic. Road salt (most often sodium chloride) readily dissolves and enters aquatic environments in ionic forms. Although chloride can originate from natural sources, most of the chloride that enters the environment is associated with the storage and application of road salt. As such, chloride-containing compounds commonly enter surface water, soil, and ground water during late-spring snowmelt (since the ground is frozen during much of the late winter and early spring).

Chloride ions are conservative, which means that they are not degraded in the environment and tend to remain in solution, once dissolved. Chloride ions that enter ground water can ultimately be expected to reach surface water and, therefore, influence aquatic environments and humans.

Acute toxicity: means an adverse effect such as mortality or debilitation caused by an exposure of 96 hours or less to a toxic substance (i.e; short period of time)

Chronic toxicity: means an adverse effect such as reduced reproductive success or growth, or poor survival of sensitive life stages, which occurs as a result of prolonged exposure to a toxic substance (i.e; long period of time)

Research has shown that elevated chloride levels can be toxic to freshwater aquatic life. Among the species tested, freshwater aquatic plants and invertebrates tend to be the most sensitive to chloride. In order to protect freshwater aquatic life in New Hampshire, the state has adopted **acute** and **chronic** chloride criteria of 860 and 230 mg/L respectively.

Chloride levels in drinking water would be unpalatable before they became toxic. The maximum contaminant level for drinking water is 250 mg/L and the recommend action level is less than 100 mg/L.

The chloride content in New Hampshire lakes is naturally low, generally less than 2 mg/L in surface waters located in remote areas away from habitation. Higher values are generally associated with salted highways and, to a lesser extent, with septic inputs.

Other Parameters

Turbidity

Turbidity in water is caused by suspended matter, such as clay, silt, and algae that cause light to be scattered and absorbed, not transmittted in straight lines through the water. Secchi disk transparency, and therefore water clarity, is strongly influenced by turbidity. High turbidity readings are often found in water adjacent to construction sites; during rain events unstable soil erodes and causes turbid water downstream. Also, improper sampling techniques (hitting the bottom of the lake with the Kemmerer bottle or stirring up the stream bottom when collecting tributary samples) may also cause high turbidity readings. The New Hampshire median for lake turbidity is 1.0 NTU. Table 11 in Appendix B lists turbidity data for 2004.

Statistical Summary of Turbidity Values for New Hampshire Lakes and Ponds

Category	Value (NTU)
Minimum	<0.1
Maximum	22.0
Median	1.0

Bacteria

Surface waters contain a variety of microorganisms including bacteria, fungi, protozoa, and algae. Most of these occur naturally and have little or no impact on human health. Health risks associated with water contact occur generally when there is contamination from human sources. Warm blooded animals such as ducks, beaver, geese, and pets can also contribute bacteria to surface waters. Contamination arises most commonly from sources of fecal waste such as failing or poorly designed septic systems, leaky sewage pipes, nonpoint source runoff from wildlife habitat areas, or inputs from wastewater treatment plant outflows within a watershed. Swimming beaches with heavy use, shallow swim areas, and/or poor water circulation also have commonly reported bacteria problems. Therefore, water used for swimming should be monitored for indicators of possible fecal contamination. Contamination is typically short-lived, since most bacteria cannot survive long in cold water; their natural environment is the gut of warm blooded animals. A recent study has shown that *E. coli* can live fairly long periods of time in the sediments.

Pathogens: disease-causing organisms

Specific types of bacteria, called indicator organisms, are the basis of bacteriological monitoring, because their presence indicates that sources of fecal contamination exist.

Indicators estimate the presence and quantity of things that cannot be meaured easily by themselves. We measure these sewage or fecal indicators rather than the **pathogens** themselves to estimate sewage or fecal contamination and, therefore, the possible risk of disease associated with using the water.

New Hampshire closely follows the bacteria standards recommended by the U.S. Environmental Protection Agency (EPA). Following a 1988 EPA report recommending the use of *E. coli* as a standard for public water supplies and human contact, DES followed suit by adopting *Escherichia coil* (*E. coli*) as the new indicator organism. The standards for Class B waters specify that no more than 406 *E. coli* counts/100 mL, or a geometric mean based on at least 3 samples obtained over a 60 day period be greater than 126 *E. coli* counts/100 mL. Designated public beach areas have more stringent standards: 88 *E. coli* counts/100 mL in any one sample, or a geometric mean of three samples over 60 days of 47 *E. coli* counts/100 mL. Table 12 shows bacteria (*E. coli*) results for 2004 and for previous sampling seasons.